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Julien Electric

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COMPANY

20 Broadway, New York.

STORAGE BATTERIES.

The Julien Electric Company.

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RICHARD ARNOLD,	VICE-PRESIDENT.
STEPHEN D. HATCH,	TREASURER.
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The Julien Electric Company.

THE JULIEN SYSTEM.

This company has been organized for the manufacture and sale of * storage batteries, together with those appliances necessary to their industrial application and use in electric traction, electric lighting, for motive power and other purposes. The company has the sole control of, and is more especially based on, the inventions of M. Edmond Julien, which are pre-eminent in this department of electricity, on account of the superior degree of perfection which they represent. These inventions embrace most important improvements in the storage battery, and the details of its manufacture, as well as in the apparatus and devices used in its application to the several purposes named. This is particularly true of the Julien system of electric traction, undoubtedly the most perfect and complete which has yet been devised. The system of storing and utilizing electricity which the Julien Electric Company is now introducing into the United States is not a mere experiment; it has the advantage of experience, and. above all, the prestige of success, achieved at Antwerp, Brussels, Hamburg, and Paris, during the last two years. These merits have additional weight, when the fact is considered that nothing practical in this line has hitherto been placed before the public.

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* The terms "Storage Battery, Accumulator and Secondary Battery," are synonymous.

STORAGE BATTERIES.

Electricity, like water, gas, steam and the like, ought to be stored, the better to admit of its use at all times and as it may be required. Indeed, it is owing to the want of a proper method of storage that electricity is not in more general use.

A proper method of storing electricity had long been the subject of serious and interesting research, but without any appreciable result, until Planté, in 1860, made known to the world the storage battery or secondary pile.

We know that under the action of a primary current the storage battery becomes a reservoir for electric energy, which it returns at will, in the form of heat, light, power, etc., so that its industrial function may be compared to that of a gasometer or cistern.

All lead-plate batteries are founded on the principle of Planté's invention—an electrode, consisting of a conducting support with active material. But on account of this very principle, based as it is upon the oxidation of the support plates (which oxidation cannot be arrested), the battery rapidly deteriorates, and is therefore of very little industrial value. Notwithstanding the many attempts at improvements upon Planté's secondary pile during the last five or six years by a large number of electricians, notably Faure, Brush, etc., the Storage Battery (which made no little noise at the time that electric lighting began to take on the development it has since acquired) did not respond to the public expectation then created, and soon fell into discredit. This condition of things was brought about by the well recognized defects of those batteries—viz., low efficiency, irregular discharge, rapid deterioration, exorbitant cost of maintenance etc. These are all defects resulting from the application of a principle which has for its basis, as well as consequence, the peroxidation of the positive support plates, whether the active matter on the plates be obtained by disintegration or addition.

It remained for EDMOND JULIEN, a Belgian engineer, to solve this important difficulty by adopting a principle diametrically opposite to the one employed by his predecessors. His batteries are made according to a new principle, that of an **inoxidizable support plate.** They are absolutely exempt from the defects inheritent in all other secondary batteries, and so have the industrial advantages which are wanting in all others. It is largely owing to the wide-spread attention which Mr. Julien's invention has attracted that storage batteries have re-entered the domain of electrical industry. In support of this statement, we cite the following facts :

I. It is by subjecting his invention to public tests and inspection that Mr. Julien has re-conquered the ground that had been lost. In 1885, on the occasion of the General Exposition at Antwerp, the Belgian Government invited the various nations to a **Trial of the Different Systems of Street Car Traction.**

The contest was begun on May 1 and lasted until October 31. "L'Electrique," a Brussels company organized for the purpose of exploiting Mr. Julien's systems in Europe, took part in that Exhibition with an ELECTRIC STREET CAR whose Motor was driven by Storage Batteries. This car, which was operated side by side with CARS PROPELLED by STEAM and COMPRESSED AIR, took **First Prize** and the **Diploma of Honor** ; at the same time the jury awarded Mr. Julien a second **Diploma of Honor** for his **Batter-**

ies. These were the highest distinctions awarded at the Exhibition. The jury which awarded these Diplomas consisted of ten members, appointed by the Governments of France, England, Germany and Belgium. In reporting on Mr. Julien's car, they speak as follows :

"The Electric Street Car very regularly performed the ordinary service with one or two cars, and the extra service, also with one or two cars, which was imposed on it.

"The two batteries of accumulators which were employed, and which seemed to have been *in use previous to the opening of the Exposition, showed no change* when they were withdrawn from service. The metal of the support plates was found to be *absolutely sound*, and the active matter adherent throughout ; no plate showed any tendency to buckling or deterioration ; this result is to be attributed to the *special composition* of the support plates made by "L'Electrique." There was an entire absence of polarization. The treatment of the batteries was confined to the replacing of the acidulated water lost by evaporation and during the charging. The battery weighed less than a ton, including boxes and liquid."

Those acquainted with the work required of a battery employed for traction, which is peculiarly trying by reason of the intense currents exacted from plates of the lightest admissible weight, and of the constant shaking of the car, will comprehend the importance of a report like the one above given. An account of the daily work done by the car may be found in the table annexed to the report of the jury. This table shows that the batteries furnished the necessary current during fifteen hours to propel the electric car, drawing another ordinary street car, both heavily laden with passengers, over a course of fifty-nine miles a day."

II. In his work on Electro-Technology (edition of 1886), the distinguished engineer, Professor Eric Gerard, of the University of Liège, says:

"In all storage batteries it has been found necessary to replace the positive electrodes, after a certain duration of service, for the reason that the lead becomes transformed into peroxide and the plates fall to pieces. Mr. Julien, of Brussels, has succeeded in prolonging the life of these electrodes by employing for their support a metallic compound which prevents their oxidation and buckling."

The author then gives the results of trials made at the University of Liège in 1885, with a battery of twenty-four elements of the Julien system. This trial was made under the supervision of the International Commission charged with testing the products exhibited at the Antwerp Exhibition.

The following are the results, already published in "THE ELECTRICAL WORLD" of New York, of November 20th, 1886:

Charge.	Duration	7 hours 33 min.
	E. M. F. per cell	2.35 volts.
	Average strength of current per kilogramme	1.86 ampères.
	Energy absorbed per kilogram	10,700 kilogrammetres.
	Ampère-hours per kilogramme	14.
Discharge.	Duration	6 hours 48 minutes.
	Final E. M. F. per cell	1.89 volts.
	Average strength of discharge per kilogramme	1.74 ampères.
	Energy given out per kilogram	86.00 kilogrammetres.
	Ampère-hours per kilogramme	11.83.
	Commercial efficiency	80%.

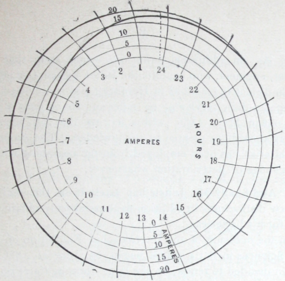
On the subject of the capacity of the accumulators and their efficiency, Mr. Gerard states that to store one electrical horse power-hour (270,000 kilogrammetres), it requires :

396 pounds of Planté accumulators ;

132 pounds of Faure accumulators with an efficiency of only 50%, according to experiments made at the "Conservatoire des Arts et Metier", in Paris.

According to the above results, $\frac{270000}{10700}$, or 55 *pounds of Mr. Julien's accumulators*, will give one electric horse power-hour with an efficiency of 80%.

III. The following diagram of discharge of a Julien battery composed of 29 cells of 88 pounds each, used by The Edison Company, in Paris, shows the efficiency and the regularity of action of the same, charged at a rate of 15 ampère-hours per 2 pounds and discharged at a rate of 13½ ampères, *with an efficiency in amperes of 90%.* It will be perceived that the Electro Motive Force of the battery was 2 volts, after 22 hours of continuous discharge.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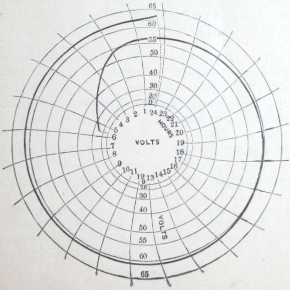
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IV. As an additional proof we would state that Mr. Huber, engineer, who exploits the Julien System (accumulators and electric traction) in Hamburg, has run electric cars in regular daily service of 59 miles in the streets of that city, since May, 1886, with a success that all scientific papers abroad are pleased to acknowledge. The same set of batteries has been employed from the beginning without any change or deterioration whatsoever.

V. And finally Mr. Julien has lately been the recipient of new distinctions in addition to those already obtained by him for his batteries.

On the occasion of the International Exhibition of Arts and Sciences in Paris, which began on June 21, 1886, Mr. Julien decided to renew, on the large thoroughfares of that capital, the official demonstrations made by him at Antwerp. Two of his cars conveyed passengers from the Place de la Concorde to the Palais de l'Industrie during the Exhibition.

The jury, presided over by M. Fontaine, President of the International Society of Electricians of France, and composed of ten eminent members of that Society, awarded Mr. Julien the **First Prize** and **Diploma of Honor** for his accumulators, and an equal distinction for his System of Electric Traction.

His competitors, who exhibited the Plantè and Faure types of accumulators, only obtained Third Class Prizes.

The confirmation of the decision of the Antwerp jury by the Paris jury is of manifest importance.

VI. We purposely abstain from citing other facts than those which, like the preceding, are publicly known and supported by official proof. These facts are sufficient to establish, beyond question, the superiority of the accumulators of this Company.

By way of comparison between the Julien and other well known Secondary Batteries—those of Faure-Sellon-Volckmar, for example—let us turn to a pamphlet recently issued by a Company engaged in manufacturing those batteries, in which we find the following data :

For a Cell weighing 125 pounds,—E. M. F.,—2 volts.
Intensity of Current, 35 ampères.
Capacity, 350 ampère-hours.

Or, a current of $\frac{28}{100}$ ampères, and a capacity of $2\frac{8}{10}$ ampère-hours per pound.

It is fair to assume that this is the very best that that battery will do. We have no proof,other than the Company's own statement, that it will even do that much.

Now, putting these figures side by side with those of *The Julien Accumulator*, given above, and as the result of *public* and *official* tests, we find :

Intensity of current per pound	Faure.	Julien.
Ampères, per pound	0.28	0.86
Capacity per pound in ampère-hours	2.8	5.38

Thus the capacity per pound of the Julien Accumulator is about *twice as great* as that of the Faure Accumulator, while the current is *three times more intense* and with a *greater* E. M. F.

Another Company claim only an E. M. F. of 1.82 volts.

These comparisons must not be regarded in the light of criticism. They are introduced solely to show the superiority of the principle of construction of the accumulators of this company, viz., an *inoxidizable support plate.*

Practical Application of the Julien Accumulator.

The Julien Accumulator can be utilized in nearly all the practical applications of electricity. In its great storing capacity, small size, reduced weight, its compactness, simplicity and durability, it surpasses all other forms of accumulators, and it is for this reason better adapted to the production of motive power, for tram-cars, launches, etc., or for electric lighting installations of any kind. Its adaptability also extends to a wide range of minor applications in the arts, in the household, the shop or laboratory. It has been extensively used and with great success, for the following purposes :

The Electric Traction of all Vehicles, more especially Street Cars.

The Utilization of Natural Forces, such as Waterfalls and Streams.

Domestic Lighting.

Running Motors of every kind.

Lighting of Railroad Cars and of Street Cars.

Medical Uses, etc., etc.

Electrical Traction.

This company makes a specialty of the application of storage batteries to the electrical traction, of vehicles, particularly street cars. In this field the Julien system recognizes no competition. Its success in various large cities of Europe has already been referred to. This success is the result of knowledge gained by the assistance of careful study and the teachings of repeated experiments in practical working. With his characteristic indefatigability, M. Julien has taken up in turn the several elements of a complete system, and with rare ingenuity has arrived in each case at the highest simplicity and perfection of detail. The Julien system is unique in the excellence of its features, covering all the principal points whereon the other systems are still in the experimental state, viz. :

THE JULIEN ACCUMULATORS.—Possessing the great capacity and durability indispensable to success.

THE JULIEN ELECTRICAL CONNECTIONS.—An entirely novel and original system, by which the various connections are made automatically by the mere act of placing the accumulators.

THE JULIEN REGULATOR.—An uncomplicated and effective device, whose operation can be understood even without teaching.

THE JULIEN MOTOR.—A compact and efficient machine, well adapted to severe usage, to which it is subjected in practical working.

THE JULIEN MECHANICAL TRANSMISSION.—Simple, noiseless and reliable.

These qualities give to our system of electrical traction a greater certainty and economy of operation than are possessed by any other known systems. With the Julien system, the propulsion of street cars by electricity, to replace horses, is no longer a doubtful experiment ; it is an established fact. The public on the one hand is clamoring for *better* service, while the shareholder wishes for *cheaper* service. The Julien system is the only one which can solve the problem to the satisfaction of both.

The Julien Electric Company is prepared to negotiate with corporations, owners, or individuals, operating or interested in, street car lines. Estimates for equipping any road will be promptly furnished on application.

Electrical Propulsion.

The many features of merit which characterize the Julien system as applied to electrical traction again recur to show its advantages for the purposes of electrical propulsion, in launches, pleasure boats, etc. There are many cases, particularly for small boats, where electrical propulsion is preferable to steam. The difficulties encountered heretofore in experiments tending toward such applications have been the great weight of accumulators, the complication of the motor and appliances for regulating or transmitting the motive power. These difficulties all vanish with the Julien system, which needs but simple modifications of detail to prove as effective and satisfactory here as it has in the case of street car traction.

Incandescent Lighting.

This is one of the most interesting and at the same time one of the most useful applications of the storage battery. It is here that its function as a reservoir of energy becomes utilized to the greatest advantage.

Where electric lights are supplied directly from the dynamo, the machinery must have a power capacity equal to the number of lights used; and since the light is usually needed during only a few hours out of each twenty-four, the plant will be idle the rest of the time. Now, by means of the storage battery, the electrical energy required can, so to speak, be prepared beforehand and stored for use. Any desired time can be taken to prepare the necessary supply, and, consequently, machinery of smaller capacity can be made to answer the purpose. Not only this, but the machinery and dynamo may be of simpler and cheaper make. In lighting directly from the dynamo, the engine must be steady and the dynamo quick regulating to prevent the flickering. With storage batteries, such irregularities can exist without particular inconvenience, and the current furnished by the batteries for lighting is always uniform and regular, even while the charging current is subject to very marked fluctuations. The storage battery is, in fact, to the dynamo what the fly-wheel is to the engine—an equalizer and a regulator. When used with dynamos that are supplying lamps direct, it eliminates all unevenness of the current; and it has the important additional advantages of affording a reserve of electrical energy, which can maintain the light for a certain time in case of accident to the dynamo or machinery.

In many shops, factories, public buildings, etc., there are times every day when power is literally running to waste. The storage battery can accumulate this waste and make it available for lighting or other purposes. There are scores of electric lighting stations in this country, particularly in the smaller cities and towns, where the plant is idle during the whole day and only earning revenue at night, or working on an average not more than eight hours out of twenty-four. Why this enforced idleness? Simply because the apparatus cannot prepare the necessary supply of electrical energy for the customer *ahead of time.* But with the storage battery these idle hours could be utilized, and the dynamos could be used during the day for storing energy in the intervals between the hours when this accumulation is consumed, just as the gas is stored in the gasholder during the day in anticipation of the evening's consumption.

On the other hand, there are instances where it is not convenient or practicable to keep the dynamos in operation during the whole time the lights are required. This is a new field for the storage battery in which it has no rival. By using a dynamo of somewhat greater capacity, the lamps can be supplied while storage batteries are being charged; and when the dynamo stops, the lamps are then supplied from the batteries. In this way it would frequently be possible to obtain the necessary power from some adjoining or neighboring factory or other establishment where the engine does not run the full time that the lights are required.

In certain applications, such as the lighting of railway trains, the storage battery affords the only practical method of using electricity. Altogether the storage battery can be made in all cases, useful, and in many cases it is indispensable, in the practical application of electricity to lighting.

Durability of the Julien Accumulator.

The uniformity of action of our batteries and especially their durability are valuable recommendations in their favor. The active material in which the electrical energy is stored is packed in supporting plates or grids made of a *new inoxidizable alloy*, discovered by M. Edmond Julien himself, as stated above. This valuable discovery renders the plates free from all danger of warping or "buckling," which is such a serious objection to all other forms of plates. At the same time the active material appears to form a better and more homogeneous contact with the surface of the grid, and the dangers from the scaling or falling away of the active material—another most serious objection to other batteries—is entirely and completely eliminated. These qualities insure great uniformity of action for the Julien batteries. The failure of a cell from loosened "plugs" or scales of active material producing local short-circuits between contiguous plates is absolutely unknown with the Julien battery.

The most crucial test of a storage battery is its use on street cars or tramways, where the possibility of derangements from the causes just mentioned is increased by the shaking and jolting which the cells receive incessantly, when the car is in motion, as well as from the somewhat excessive currents which the battery is sometimes required to furnish. In the case of all other forms of storage battery yet tried for this work, the necessity for repairs has invariably shown itself inside of a year. With the Julien battery some cells which were already old when entered for the test at the Antwerp Exposition, and which were used almost daily for months afterwards, are still in very good condition. The negative plates are in excellent order. The positive plates are *not perceptibly corroded*, and apparently the only damage they have sustained arose from the constant friction of the solution due to the shaking motion, by which a part of the active material has become washed away, like the beach by the action of the waves. In stationary plants this source of wear and tear would not exist.

The Julien Electric Company does not hesitate to warrant its batteries for two years when used with reasonable care and in accordance with the instructions. If these instructions are closely followed, the period of two years does not by any means give the limit of their endurance. The cells should still be capable of service after a thousand charges. The negative plates appear to be capable of lasting indefinitely; so that only the nine positive plates or $\frac{9}{19}$ of each cell are likely to require repairs or removal. If the cells were never *over-discharged* or left standing without charge, the principal cause of detriment to the positive plate would be removed. But these conditions cannot always be followed closely in practice. The cost of renewal of the positive plates is, however, partly covered by the value of the old plates.

Practical Information and Instructions.

Details of the Julien Accumulator.

The standard accumulator of this company is that known as type B. It consists of 19 plates, 9 being positive and 10 negative, weighing 27 lbs. net, *i.e.*, without the containing box or the acid solution, which make an additional weight of from 6 to 7 lbs. The positive plates are indicated by red paint on the connecting strip. Following are the principal details of the type B accumulator :—

Floor space	6½ x 5¾ inches.
Height	8 "
Net weight	27 lbs.
Total	34 "
Quantity of solution	about 1¾ quarts.
Strength " " in degrees Baumé	23°
" " " " specific gravity	1.185

Electro-motive force	2 volts.
Internal resistance	.001 to .005 ohm.
Current of charge	up to 18 ampères.
" " discharge	" " 36 "
Current capacity of each accumulator	125 ampère-hours.
Energy capacity " " " (C.Et.)	250 volt ampère-hours or watt-hours.

Storage Capacity for Incandescent Lighting.

At first sight the rules by which electricians calculate the amount of electrical energy involved in a given application of electricity seem mysterious and complex. Yet in reality these rules are simple enough, if once the units and terms employed, and their relation to each other, are understood. The few definitions and explanations given here are sufficient to enable any person to understand and apply the rules by which the various calculations relating to the use of the storage battery in electric lighting can be effected.

Total Electrical Energy Required.

It requires a certain definite electrical pressure to overcome the resistance of an incandescent lamp and to force through it the volume of current necessary to make it give its normal light. This pressure is estimated by reference to a certain unit called the volt, while the volume of current is measured in units called ampères. Multiply the volts by the ampères, the product obtained is *volt ampères*, more generally called watts. The watts indicate the rate at which the electrical energy is consumed, and since 746 watts are the electrical equivalent of energy expended at the rate of one horse-power, we can estimate the rate of consumption in horse power. Thus from the volts and ampères required by a lamp we can estimate the amount of electrical energy necessary for any given number. For example a 16 candle-power lamp of a given make requires a current of 100 volts pressure and of a volume of 0.75 ampère, the product of the volts and ampères is 75; hence this lamp consumes energy at the rate of 75 watts. Another lamp, with a shorter or thicker filament, offering less resistance, requires less pressure, say 50 volts, but needs more current, say 1.5 ampère, to develop 16 candle-power. This lamp would also be called a 75 watt lamp, because the product of its volt ampères is also 75. Now if ten lamps of either kind are to be maintained at once, the energy must be supplied at ten times the rate, and consequently we must have an electrical current of 750 watts, or a trifle over one electrical horse-power.

The number of watts indicates the rate of consumption of energy. In order to estimate the total amount consumed or to be supplied we must evidently include the time during which the consumption is to be continued. For example, the work done by an engine is estimated by multiplying its horse-power by the number of hours during which it is run. An engine of one horse-power, working ten hours, supplies ten horse-power hours of energy or just as much as a ten horse-power engine in one hour. In the same way the total amount of electrical energy consumed in a given time is obtained by taking the rate or power of the current and the hours. Thus if 746 watts represent the rate or power of a given current, then 746 watt-hours would represent the total energy developed by this current in one hour; and inasmuch as 746 watts are equivalent to one horse-power, so 746 watt-hours are equivalent to one horse-power hour. It is evident then that the total energy required by a 75 watt lamp for a given time can be measured in watt-hours. For one hour it would require 75 watt-hours of electrical energy. For ten hours it would require 750 watt-hours, or as much as ten such lamps in one hour. Different kinds of lamps vary slightly in the number of watts which they require to produce a given light, but as long as we refer to the same lamp, we may say that each "lamp-hour" requires a definite number of watt-hours. For example with the lamps above referred to, each lamp-hour is equal to 75 watt-hours.

The following rules are all based on the principle just defined:

1. To find the watts in a given electrical circuit, such as in a lamp, multiply the volts by the ampères.

2. To find the volts, divide the watts by the ampères.

3. To find the ampères, divide the watts by the volts.

4. To find the electrical horse-power required by a lamp, divide the watts of the lamp by 746.

5. To find the number of lamps that can be supplied by one electrical horse-power of energy, divide 746 by the watts of the lamps.

6. To find the watt-hours of the lamp, or the total electrical energy it will require, multiply the watts by the number of hours the lamp is to burn.

7. To find the lamp-hours of light of a given installation, multiply the number of lamps by the average hours

of lighting. Example, 100 lights burning six hours=600 lamp hours.

8. To find the total electrical energy necessary, multiply the lamp-hours by the watts per lamp. Example, 600 lamp-hours, using lamps of 75 watts=45,000 watt-hours.

9. To find the electrical horse-power-hours of energy required for the installation, divide the total watt-hours by 746. Example, 45,000 ÷ 746=60.32 electrical horse-power-housr.

10. To find the horse-power necessary for the work of charging, divide the eleetrical horse-power-hours by the hours allowed for charging and add sufficient percentage to cover all losses in engine dynamo, batteries, etc. Example, taking the charging time at ten hours $\frac{60.32}{10} = 6.03$, adding 50 per cent. 6.032 + 3-016 = 9.48 horse-power.

Number and Arrangement of Accumulators.

The preceding rules show how to estimate the total energy that the accumulators must supply in maintaining a given number of lamps for a stated time. It remains now to determine how many accumulator cells will be required, and how they must be connected, to provide the electrical energy at the proper rate and for the desired time.

Since each type of lamp requires a current of a certain number of volts, we must connect cells in series in sufficient number to obtain this electro-motive force. Each accumulator cell of type B gives an average E.M.F. of 2 volts during discharge, and the number of cells connected in series must, therefore, be equal to the volts of the lamp used, divided by 2. Thus for lamps of 100 volts, 50 cells in series will be necessary, no matter whether one lamp or many are burning. Each of the 50 cells will then contribute, per lamp 2 volts and 0.75 ampère or 1.5 watts, that is to say, $\frac{1}{50}$ of the energy (75 watts) consumed by the lamp. Each additional lamp will absorb an equal amount from each cell, since it will increase the current discharge by 0.75 ampère.

The number of lamps can therefore be increased until the current passing through the series of cells reaches the maximum rate of discharge for the cell, or 36 ampères, as above, it being always remembered that a large number of lamps will more quickly exhaust the supply of electrical energy contained in the cell than would a smaller number. At 0.75 ampère per lamp it would require 48 lamps to raise the discharge current to 36 ampères. At this maximum rate of discharge each cell is supplying 72 watt-hours per hour, and its charge of 250 watt-hours will, therefore, last about 3½ hours. If we wish to maintain the lights for a longer time, say 6 hours, we must discharge the cells at a slower rate; in other words, we must put on fewer lamps. The 250 watt-hours in each cell must last 6 hours, and, therefore, we must draw only one-sixth of this amount per hour, or about 42 watt-hours. Each lamp draws only 1.5 watt-hour per lamp hour from each of the 50 cells; therefore, 42 watt-hours per hour will suffice for 28 lamps. In other words, a series of 50 cells will maintain 28 lamps of 75 watts for 6 hours.

Suppose, now, that we unite two such series by connecting terminals of same polarity together. The effect will be the same as if we had a single series of cells, each having the same E M.F., but twice the current capacity and discharge rate. Consequently this double series could supply 56 lamps for 6 hours. If only 50 lights were required the double series of 50 or in all 100 cells would still be necessary. The supply would then last longer, or if not needed the cells need not be discharged entirely. For 100 lamps 4 series of 50; or in all 200, cells would be necessary, although the same storage capacity would suffice for 112 lights. By using lamps of different voltage, however, it is possible to provide for 100 lamps with less than 200 cells. We found, by rule 8 above, that for 100 lamps of 75 watts, burning 6 hours, the total electrical energy to be supplied is 45,000 watt hours. Now, theoretically,since each accumulator cell has a capacity of 250 watt-hours, then 180 cells would be just sufficient to store this energy. The series of cells must all be equal, and to make an equal or greater number of even series from a smaller number of cells the series must be shorter. This means that the voltage of the lamps must be reduced. Let us take lamps of 60 volts, and of the same rate, 75 watts. Then 30 cell in series will give the 60 volts E.M.F. necessary. Out of 180 cells we can make exactly 6 such series. Each cell will now furnish $\frac{1}{30}$ the energy required per lamp, which, for a 75 watt lamp, will be 2.5 watt hours per hour. The maximum rate of supply of each cell is, as before, nearly 42 watt-hours per hour. Each series can, therefore, maintain $\frac{42}{2.5}=16\frac{2}{3}$ lamps, and the 6 series would maintain 6 times as many, or 100 lamps. Thus by using the 60 volt lamps we can dispense with 20 cells, and the theoretical number of cells is sufficient. In practice it is desirable to use one or two supplementary cells with each series. At the beginning of the discharge the cells give somewhat more than 2 volts each, and one or two less than the normal number of cells are at first included in circuit, the others being added later. On the other hand, toward the end of the discharge the E.M.F. may fall a little below 2 volts per cell, and in this case it is an advantage to add one or two supplementary cells to maintain the E. M.F. at the normal value.

The foregoing explanations may be summarized in practical rules as before:

11. To find the theoretical number of cells necessary to store a given amount of electrical energy, divide the total energy in watt-hours by the energy capacity of one cell in watt-hours.

Example : 45,000 to be stored in type B cell.

$$\frac{45{,}000}{250} = 180 \text{ cells required.}$$

12. To find how many cells must be connected in each series for lamps of given voltage ; divide the volts of the lamps by two.

13. To find the proportion of energy drawn from each cell in a series ; divide the watts of the lamp by the number of cells in series.

Example : A 60 volt lamp of 75 watts, requiring 30 cells in series.

$$\frac{75 \text{ watts}}{30 \text{ cells}} = 2.5 \text{ watts per cell per lamp.}$$

14. To find the average rate at which cell must discharge

in order to last a given time : divide the watt-hours of the cell by the average hours of lighting.

Example : The discharge is required to occupy 6 hours.

$$\frac{250 \text{ watt-hours}}{6 \text{ hours}} = 41\tfrac{2}{3} \text{ watt-hours discharge per hour.}$$

15. To find the number of lamps which can be supplied for a given number of hours by a series of cells ; divide the rate of discharge per cell by the rate required per cell per lamp.

Example : $41\tfrac{2}{3} \div 2\tfrac{1}{2} = 16\tfrac{2}{3}$ lamps of 60 volts from 30 cells of 6 hours.

16. To find the number of series of cells required for a given number of lamps burning a given number of hours ; divide the number of lamps by the lamps per series.

Example : To light 110 lamps of 60 volts (75 watts) for 6 hours.

$$\frac{110 \text{ lamps}}{16\tfrac{2}{3} \text{ lamps per series}} = 6\tfrac{2}{3} \text{ series.}$$

As all the series must be equal, we must take 7 series. Each series being 30 we have 210 cells.

When orders are filled our customers will be furnished with a pamphlet giving detailed practical information on storage batteries, with some useful advice and instructions on the arrangement and management of the installation.

THE JULIEN ELECTRIC COMPANY,
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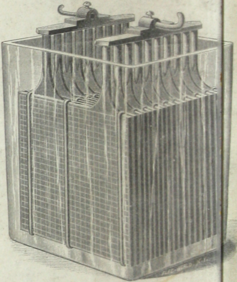

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